SERIAL 03057 -RFP FLOOD FORECASTING AND STORM MODELING (NIGP 920-07)

CONTRACT PERIOD THROUGH OCTOBER 31, 2004

TO: All Departments

FROM: Department of Materials Management

SUBJECT: Contract for **FLOOD FORECASTING AND STORM MODELING (NIGP 920-07)**

Attached to this letter is published an effective purchasing contract for products and/or services to be supplied to Maricopa County activities as awarded by Maricopa County on **November 05, 2003.**

All purchases of products and/or services listed on the attached pages of this letter are to be obtained from the vendor holding the contract. Individuals are responsible to the vendor for purchases made outside of contracts. The contract period is indicated above.

Wes Baysinger, Director
Materials Management

CS/mm
Attach

Copy to: Clerk of the Board
Glen Card, Flood Control District
Gabriela Varadi, Flood Control District
Bing Zhao, Flood Control District
Sharon Tohtsoni, Materials Management

(Please remove Serial 03012-RFP from your contract notebooks)

DRAFT CONTRACT
CONTRACT PURSUANT TO RFP

SERIAL 03057-RFP

This Contract is entered into this 16th day of October, 2003 by and between Maricopa County ("County"), a political subdivision of the State of Arizona, and Cybernology, Inc, an Virginia corporation ("Contractor") for the purchase of Flood Forecasting and Storm Modeling services.

1.0 TERM

1.1 This Contract is for a term of one (1) years, beginning on the 1st day of November 2003 and ending the 31st day October of 2004.

1.2 The County may, at its option and with the agreement of the Contractor, extend the period of this Contract for additional one (1) year terms up to a maximum of one (1) additional terms. The County shall notify the Contractor in writing of its intent to extend the Contract period at least thirty (30) calendar days prior to the expiration of the original contract period, or any additional term thereafter.

2.0 PAYMENT

2.1 As consideration for performance of the duties described herein, County shall pay Contractor the sum stated in Final Pricing, attached hereto and incorporated herein as Exhibit "A." Payment shall be made as set forth in the RFP and/or the Best and Final Offer.

2.2 Payment under this Contract shall be made in the manner provided by law. Invoices shall be prepared and submitted in accordance with the instructions provided on the purchase order. Invoices shall contain the following information: purchase order number, item numbers, description of supplies and/or services, sizes quantities, unit prices, and extended tot als and applicable sales/use tax. The County is not subject to excise tax.

3.0 DUTIES

3.1 The Contractor shall perform all duties stated in the Agreed Scope of Work, attached hereto and incorporated herein as Exhibit "B."

3.2 Contractor shall perform services at the location(s) and time(s) stated in Exhibit "B," or in the purchase order requesting such services.

3.3 During the Contract term, County shall provide Contractor's personnel with adequate workspace for consultants and such other related facilities as may be required by Contractor to carry out its contractual obligations.

4.0 TERMS & CONDITIONS

4.1 INDEMNIFICATION AND INSURANCE:

4.1.1 **INDEMNIFICATION**

To the fullest extent permitted by law, CONTRACTOR shall defend, indemnify, and hold harmless **COUNTY**, its agents, representatives, officers, directors, officials, and employees from and against all claims, damages, losses and expenses, including, but not limited to, attorney fees, court costs, expert witness fees, and the cost of appellate proceedings, relating to, arising out of, or alleged to have resulted from the acts, errors, omissions or mistakes relating to the performance of this Contract. **CONTRACTOR'S** duty to defend, indemnify and hold harmless **COUNTY**, its agents, representatives, officers, directors, officials, and employees shall arise in connection with any claim, damage, loss or expense that is attributable to bodily injury, sickness, disease, death, or injury to, impairment, or destruction of property, including loss of use resulting therefrom, caused by any acts, errors, omissions or mistakes in the performance of this Contract including any person for whose acts, errors, omissions or mistakes **CONTRACTOR** may be legally liable.

The amount and type of insurance coverage requirements set forth herein will in no way be construed as limiting the scope of the indemnity in this paragraph.

4.1.2 **Abrogation of Arizona Revised Statutes Section 34-226:**

In the event that A.R.S. § 34-226 shall be repealed or held unconstitutional or otherwise invalid by a court of competent jurisdiction, then to the fullest extent permitted by law, **CONTRACTOR** shall defend, indemnify and hold harmless **COUNTY**, its agents, representatives, officers, directors, officials and employees from and against all claims, damages, losses and expenses (including but not limited to attorney fees, court costs, and the cost of appellate proceedings), relating to, arising out of, or resulting from **CONTRACTOR'S** work or services. **CONTRACTOR'S** duty to defend, indemnify and hold harmless, **COUNTY**, its agents, representatives, officers, directors, officials and employees shall arise in connection with any claim, damage, loss or expense that is attributable to bodily injury, sickness, disease, death, injury to, impairment or destruction of property including loss of use resulting therefrom, caused in whole or in part by any act or omission of **CONTRACTOR**, anyone **CONTRACTOR** directly or indirectly employs or anyone for whose acts **CONTRACTOR** may be liable, regardless of whether it is caused in part by a party indemnified hereunder, including **COUNTY.**

The scope of this indemnification does not extend to the sole negligence of **COUNTY**.

4.1.3 Insurance Requirements.

CONTRACTOR, at **CONTRACTOR'S** own expense, shall purchase and maintain the herein stipulated minimum insurance from a company or companies duly licensed by the State of Arizona and possessing a current A.M. Best, Inc. rating of B++6. In lieu of State of Arizona licensing, the stipulated insurance may be purchased from a company or companies which are authorized to do business in the State of Arizona, provided that said insurance companies meet the approval of **COUNTY**. The form of any insurance policies and forms must be acceptable to **COUNTY**.

All insurance required herein shall be maintained in full force and effect until all work or service required to be performed under the terms of the Contract is satisfactorily completed and formally accepted. Failure to do so may, at the sole discretion of **COUNTY**, constitute a material breach of this Contract.

CONTRACTOR'S insurance shall be primary insurance as respects **COUNTY**, and any insurance or self-insurance maintained by **COUNTY** shall not contribute to it.

Any failure to comply with the claim reporting provisions of the insurance policies or any breach of an insurance policy warranty shall not affect coverage afforded under the insurance policies to protect **COUNTY**.

The insurance policies may provide coverage which contains deductibles or self-insured retentions. Such deductible and/or self-insured retentions shall not be applicable with respect to the coverage provided to **COUNTY** under such policies. **CONTRACTOR** shall be solely responsible for the deductible and/or self-insured retention and **COUNTY**, at its option, may require **CONTRACTOR** to secure payment of such deductibles or self-insured retentions by a surety bond or an irrevocable and unconditional letter of credit.

COUNTY reserves the right to request and to receive, within 10 working days, certified copies of any or all of the herein required insurance policies and/or endorsements. **COUNTY** shall not be obligated, however, to review such policies and/or endorsements or to advise **CONTRACTOR** of any deficiencies in such policies and endorsements, and such receipt shall not relieve **CONTRACTOR** from, or be deemed a waiver of **COUNTY'S** right to insist on strict fulfillment of **CONTRACTOR'S** obligations under this Contract.

The insurance policies required by this Contract, except Workers' Compensation, shall name **COUNTY**, its agents, representatives, officers, directors, officials and employees as Additional Insureds.

The policies required hereunder, except Workers' Compensation, shall contain a waiver of transfer of rights of recovery (subrogation) against **COUNTY**, its agents, representatives, officers, directors, officials and employees for any claims arising out of **CONTRACTOR'S** work or service.

4.1.3.1 Commercial General Liability. **CONTRACTOR** shall maintain Commercial General Liability Insurance (CGL) and, if necessary, Commercial Umbrella Insurance with a limit of not less than $1,000,000 for each occurrence with a $2,000,000 Products/Completed Operations Aggregate and a $2,000,000 General Aggregate Limit. The policy shall include coverage for bodily injury, broad form property damage, personal injury, products and completed operations and blanket contractual coverage including, but not limited to, the liability assumed under the indemnification provisions of this Contract which coverage will be at least as broad as Insurance Service Office, Inc. Policy Form CG 00 01 10 93 or any replacements thereof. There shall be no endorsement or modification of the CGL limiting the scope of coverage for liability arising from explosion, collapse, or underground property damage.

The policy shall contain a severability of interest provision, and shall not contain a sunset provision or commutation clause, or any provision which would serve to limit third party action over claims.

The CGL and the commercial umbrella coverage, if any, additional insured endorsement shall be at least as broad as the Insurance Service Office, Inc.'s Additional Insured, Form CG 20 10 10 01, and shall include coverage for **CONTRACTOR'S** operations and products.

4.1.3.2 Automobile Liability. **CONTRACTOR** shall maintain Automobile Liability Insurance and, if necessary, Commercial Umbrella Insurance with a combined single limit for bodily injury and property damage of no less than $1,000,000, each occurrence, with respect to **CONTRACTOR'S** vehicles (including owned, hired, non-owned), assigned to or used in the performance of this Contract. If hazardous substances, materials, or wastes are to be transported, MCS 90

endorsement shall be included and $5,000,000 per accident limits for bodily injury and property damage shall apply.

4.1.3.3 Workers' Compensation. **CONTRACTOR** shall carry Workers' Compensation insurance to cover obligations imposed by federal and state statutes having jurisdiction of **CONTRACTOR'S** employees engaged in the performance of the work or services, as well as Employer's Liability insurance of not less than $100,000 for each accident, $100,000 disease for each employee, and $500,000 disease policy limit.

CONTRACTOR waives all rights against **COUNTY** and its agents, officers, directors and employees for recovery of damages to the extent these damages are covered by the Workers' Compensation and Employer's Liability or commercial umbrella liability insurance obtained by **CONTRACTOR** pursuant to this agreement.

In case any work is subcontracted, **CONTRACTOR** will require the Subcontractor to provide Workers' Compensation and Employer's Liability insurance to at least the same extent as required of **CONTRACTOR**.

4.1.4 Certificates of Insurance.

4.1.4.1 Prior to commencing work or services under this Contract, Contractor shall furnish the County with certificates of insurance, or formal endorsements as required by the Contract in the form provided by the County, issued by Contractor's insurer(s), as evidence that policies providing the required coverage, conditions and limits required by this Contract are in full force and effect. Such certificates shall identify this contract number and title.

4.1.4.2 In the event any insurance policy(ies) required by this contract is(are) written on a "claims made" basis, coverage shall extend for two years past completion and acceptance of **CONTRACTOR'S** work or services and as evidenced by annual Certificates of Insurance.

If a policy does expire during the life of the Contract, a renewal certificate must be sent to **COUNTY** fifteen (15) days prior to the expiration date.

4.1.4.3 Cancellation and Expiration Notice.

Insurance required herein shall not be permitted to expire, be canceled, or materially changed without thirty (30) days prior written notice to the County.

4.1 REQUIREMENT OF CONTRACT BOND:

Concurrently with the submittal of the Contract, the Contractor shall furnish the Contracting Agency the following bonds, which shall become binding upon the award of the contract to the Contractor.

(A) A Performance Bond equal to 100% of the full Contract amount conditioned upon the faithful performance of the Contract in accordance with plans, specifications and conditions thereof. Such bond shall be solely for the protection of the Contracting Agency awarding the Contract.

Each such bond shall include a provision allowing the prevailing party in a suit on such bond to recover as a part of his judgment such reasonable attorney's fees as may be fixed by a judge of the court.

Each bond shall be executed by a surety company or companies holding a certificate of authority to transact surety business in the State of Arizona issued by the Director of the Department of Insurance. The bonds shall not be executed by an individual surety or sureties. The bonds shall be made payable and acceptable to the Contracting Agency. The bonds shall be written or countersigned by an authorized representative of the surety who is either a resident of the State of Arizona or whose principal office is maintained in this state, as by law required, and the bonds shall have attached thereto a certified copy of the Power of Attorney of the signing official. In addition, said company or companies shall be rated "Best-A" or better as required by the Contracting Agency, as currently listed in the most recent Best Key Rating Guide, published by the A.M. Best Company.

In lieu of the performance bond requirement, the County will accept a 30-40% hold back on all invoices for each phase of the project. Invoices will be paid as submitted for each task/phase and the County will pay short all invoices 30-40% of the total billed for each task/phase. At the completion of each phase, the contractor must obtain written acceptance from the County's Flood Control District project manager in order to receive the 30-40% paid short.

4.2 NOTICES:

All notices given pursuant to the terms of this Contract shall be addressed to:

For County:

Maricopa County
Department of Materials Management
Attn: Corry Slama
320 West Lincoln Street
Phoenix, Arizona

For Contractor:

Junping Wang, PhD.
Cybernology, Inc.
1024 N. Utah Street., Suite #722
Arlington, VA 22201

4.3 REQUIREMENTS CONTRACT:

Contractor signifies its understanding and agreement by signing this document, that this Contract is a requirements contract. This Contract does not guarantee any purchases will be made. Orders will only be placed when County identifies a need and issues a purchase order.

Contractor shall take no action under this Contract unless specifically requested by County, which shall submit a written purchase order to Contractor requesting that work be performed or product be delivered.

County reserves the right to cancel purchase orders within a reasonable period of time after issuance. Should a purchase order be canceled, the County agrees to reimburse the Contractor for actual and documented costs incurred by the Contractor pursuant to the purchase order. The County will not reimburse the Contractor for any costs incurred after receipt of cancellation, or for lost profits, or shipment of product or performance of services prior to issuance of a purchase order.

Contractor agrees to accept verbal cancellation of purchase orders.

4.4 ESCALATION:

Any requests for reasonable price adjustments must be submitted thirty (30) days prior to the Contract expiration date. Requests for adjustment in cost of labor and/or materials must be supported by appropriate documentation. If County agrees to the adjusted price terms, County shall issue written approval of the change. The reasonableness of the request will be determined by comparing the request with the Producer Price Index or by performing a market survey.

4.5 TERMINATION:

County may unconditionally terminate this Contract for convenience by providing thirty (30) calendar days advance notice to the Contractor.

County may terminate this Contract if Contractor fails to pay any charge when due or fails to perform or observe any other material term or condition of the Contract, and such failure continues for more than ten (10) days after receipt of written notice of such failure from County, or if Contractor becomes insolvent or generally fails to pay its debts as they mature.

4.6 STATUTORY RIGHT OF CANCELLATION FOR CONFLICT OF INTEREST:

Notice is given that pursuant to A.R.S. § 38-511 the County may cancel this Contract without penalty or further obligation within three years after execution of the contract, if any person significantly involved in initiating, negotiating, securing, drafting or creating the contract on behalf of the County is at any time while the Contract or any extension of the Contract is in effect, an employee or agent of any other party to the Contract in any capacity or consultant to any other party of the Contract with respect to the subject matter of the Contract. Additionally, pursuant to A.R.S § 38-511 the County may recoup any fee or commission paid or due to any person significantly involved in initiating, negotiating, securing, drafting or creating the contract on behalf of the County from any other party to the contract arising as the result of the Contract.

4.7 OFFSET FOR DAMAGES;

In addition to all other remedies at law or equity, the County may offset from any money due to the Contractor any amounts Contractor owes to the County for damages resulting from breach or deficiencies in performance under this contract.

4.8 ADDITIONS/DELETIONS OF SERVICE:

The County reserves the right to add and/or delete products and/or services provided under this Contract. If a requirement is deleted, payment to the Contractor will be reduced proportionately to the amount of service reduced in accordance with the proposal price. If additional services and/or products are required from this Contract, prices for such additions will be negotiated between the Contractor and the County.

4.9 SUBCONTRACTING:

The Contractor may not assign this Contract or subcontract to another party for performance of the terms and conditions hereof without the written consent of the County, which shall not be unreasonably withheld. All correspondence authorizing subcontracting must reference the Proposal Serial Number and identify the job project.

4.10 AMENDMENTS:

All amendments to this Contract must be in writing and signed by both parties.

4.11 RETENTION OF RECORDS:

The Contractor agrees to retain all financial books, records, and other documents relevant to this Contract for five (5) years after final payment or until after the resolution of any audit questions

which could be more than five (5) years, whichever is longer. The County, Federal or State auditors and any other persons duly authorized by the Department shall have full access to, and the right to examine, copy and make use of, any and all said materials.

If the Contractor's books, records and other documents relevant to this Contract are not sufficient to support and document that requested services were provided, the Contractor shall reimburse Maricopa County for the services not so adequately supported and documented.

4.12 AUDIT DISALLOWANCES:

If at any time County determines that a cost for which payment has been made is a disallowed cost, such as overpayment, County shall notify the Contractor in writing of the disallowance. County shall also state the means of correction, which may be but shall not be limited to adjustment of any future claim submitted by the Contractor by the amount of the disallowance, or to require repayment of the disallowed amount by the Contractor.

4.13 VALIDITY:

The invalidity, in whole or in part, of any provision of the Contract shall not void or affect the validity of any other provision of this Contract.

4.14 RIGHTS IN DATA:

The County shall have the use of data and reports resulting from this Contract without additional cost or other restriction except as provided by law. Each party shall supply to the other party, upon request, any available information that is relevant to this Contract and to the performance hereunder.

4.15 INTEGRATION

This Contract represents the entire and integrated agreement between the parties and supersedes all prior negotiations, proposals, proposals, communications, understandings, representations, or agreements, whether oral or written, express or implied.

IN WITNESS WHEREOF, this Contract is executed on the date set forth above.

CONTRACTOR

_____
AUTHORIZED SIGNATURE

_____
PRINTED NAME AND TITLE

_____
ADDRESS

_____
DATE

MARICOPA COUNTY

BY: _____ _____
DIRECTOR, MATERIALS MANAGEMENT DATE

BY: _____ _____
CHAIRMAN, BOARD OF SUPERVISORS DATE

ATTESTED:

_____ _____
CLERK OF THE BOARD DATE

APPROVED AS TO FORM:

_____ _____
MARICOPA COUNTY ATTORNEY DATE

CYBERNOLOGY INC., 1024 N UTAH ST #722, ARLINGTON, VA 22201

SERIAL BS 03057-RFP
PRICING SHEET S07 37 07/B0603400/NIGP 920-07

BIDDER NAME:	Cybernology Inc.
F.I.D./VENDOR #:	14-1888463
BIDDER ADDRESS:	1024 N Utah ST. #722, Arlington, VA 22201
P.O. ADDRESS:	
BIDDER PHONE #:	(703) 248-0663 / (303) 941-9308
BIDDER FAX #:	(703) 248-0663
COMPANY WEB SITE:	
COMPANY CONTACT (REP):	Dr. Junping Wang, Presiden
E-MAIL ADDRESS (REP):	jwang@mines.edu

PAYMENT TERMS: Net 30 Days

1.0 PRICING:

PHASE I

Task 1.1	$0
Task 1.2	$0
Task 1.3	$21,240
TOTAL COST PHASE I	$21,240

PHASE II

Task 2.1	$7,080
Task 2.2	$14,160
Task 2.3	$7,080
Task 2.4	$28,320
Task 2.5	$10,620
Task 2.6	$10,620
Task 2.7	$7,080
TOTAL COST PHASE II	$84,960
TOTAL COST PHASE III	$63,720
TOTAL COST ALL PHASES	$169,920

Exhibit B

SERIAL 03057-RFP

1.0 SCOPE OF WORK:

1.1 Project Purposes:

The purpose of this scope of work shall be to develop efficient algorithms and software to solve surface and subsurface flow partial differential equations (PDEs) for real-time flood forecasting and design storm modeling. The differences between the real-time flood forecasting and design storm modeling are in the input rainfall data. The input rainfall data for the real-time flood forecasting are based on Maricopa County's ALERT gage data and NWS radar rainfall data (both are real-time) while the input rainfall data for the design storm modeling are based on 100-year design storms. In addition, the design storm modeling requires a post-process to interpolate the results based on index 100-year design storms. This project will consist of three (3) phases: Phase 1 is the development of efficient algorithms for solving distributed surface flow equations in conjunction with simplified sub-surface flow or rainfall infiltration equations. Phase 2 is the software development based on the algorithms developed in Phase 1. Phase 3 is real-time parameter calibration for real-time flood forecasting and post-processing for design storm modeling. **Each of the requirements of the three phases of this scope of work will be satisfied in accordance with the Best and Final Offer submitted by Cybernology (dated 09/04/03)**. Cybernology shall prepare a detailed project schedule and the cost estimated for each task. The schedule and cost estimate shall be submitted to FCDMC for approval within fifteen (15) days after the project starts. A tele-conference shall be held for the kick-off meeting. A meeting or tele-conference shall be held after FCDMC reviews each progress report. A minimum of two meeting shall be held at FCDMC between FCDMC's staff and Cybernology's key staff for the software demonstration, deliverables, and software/hardware installation.

1.2 Phase 1: Solution Algorithm Development for Surface/Sub-surface PDEs

Phase 1 is the development of efficient algorithms for solving distributed surface flow equations in conjunction with simplified sub-surface flow or rainfall infiltration equations. It has three parts: Part #1: Literature search/review/analysis in the field of hydrologic/hydraulic engineering, Part #2: Literature search/review/analysis in the field of numerical analysis/computational mathematics, and Part #3: PDEs and algorithm development for surface and sub-surface flow.

A report shall be submitted to the Flood Control District of Maricopa County (FCDMC) about the findings in this phase for review and approval. The report shall be in both hard copy and digital format (MS Word or PDF).

FCDMC will provide necessary data and reports for software development and verifications ONLY. No data and reports should be used for commercial use. FCDMC's information-requesting forms shall be filled out and notarized by consultants.

1.2.1 Task 1.1 Literature Search/Review/Analysis ------ Hydrologic/Hydraulic Engineering

In this phase, literature search/review shall be conducted in the field of hydrologic/hydraulic engineering to collect and analyze the existing methodologies, algorithms, and software packages for solving similar flood modeling problems. The surface flow PDEs are continuity and momentum equations (2D or 3D) for incompressible homogeneous fluid. The typical PDEs used in the field of hydraulic modeling are 2-dimensional Saint Venant equations (continuity and momentum equations). The sub-surface flow equations include rainfall infiltration equations such as Green-Ampt infiltration equations, Richards equation (based on Darcy's Law), and simplified ground water modeling PDEs for interflow. The literature for the most recent real-time rainfall-runoff forecasting based on 2-dimensional or 3-dimensional flow modeling shall be collected and investigated. The software packages to be investigated shall include, but not limited to, the following 2-dimensional flow packages: RMA2, FESWMS, DHM, FLO-2D, CASC2D, RIBS, and tRIBs. Reports for some of the software packages may be obtained from FCDMC. The literature search/review shall also include the modeling of hydraulic structures such as culverts, bridges, and storm drains.

1.2.2 Task 1.2 Literature Search/Review/Analysis ------ Numerical Analysis/Computational Mathematics

The literature search/review shall also include the collection and analyses of the existing methodologies, algorithms, and software packages in the field of numerical analysis and computational mathematics for solving similar flow problems. The issues of computation performance, accuracy, convergence, and stability shall be addressed in the literature review. The literature to be collected/analyzed include, but not limited to, the following methodologies: domain decomposition, parallel computing, multigrid, finite volume, finite element, finite difference, level set method, and so on.

1.2.3 Task 1.3 PDEs and Algorithms Development for Surface/Sub-surface Flow

Different sets of PDEs in terms of different levels of complexity and solution efficiency shall be derived/simplified from the Navier-Stokes equations and other fluid mechanics/hydraulics equations. The corresponding algorithms shall be analyzed and developed. The "easiest" PDEs corresponding to the least computation time shall be used for prototyping purpose.

Efficient algorithms are critical in this project. The definition of "efficient algorithms" is that the final product (software) will be able to forecast the flow depth and velocity for flash flood. Timing is critical for flash flood forecasting. For example, a reasonable time interval such as 6-minute may be the forecasting time interval, i.e., the equations are solved every 6-minute to compute the flow depth and velocity for the following 3-hour time period for the entire County. However, the final forecasting interval shall be determined based on the results of the prototyping stage in Phase 2.

The software shall simulate flow within hydraulic structures such as culverts, bridges, and storm drains which are not directly reflected in the topographic

data. The interaction between the hydraulics structures and the distributed modeling shall be developed.

1.3 Phase 2: Software Development for Surface/Sub-surface PDEs

Phase 2 is the software development which includes several stages: preliminary design, detailed design, testing plan development, coding and unit testing, system testing, acceptance testing, documentations, and deliverables. The preliminary design is to identify the major tasks, functions, procedures, or object-oriented classes. A general framework of the software shall be designed in the preliminary design. The detailed design is to elaborate the preliminary design to produce "code-to" specifications. The testing plan development stage shall outline the testing procedures and details. Coding includes prototyping and the full implementation of the algorithms by using the latest version of C++ or FORTRAN. Prototyping is to solve the "easiest" PDEs which require the least computation time without losing much accuracy. The acceptable flow depth error may be 0.5 feet for the prototyping version of the software. The acceptable velocity error may be 1 ft/sec for the prototyping version of the software. The full implementation of the algorithms shall be expanded based on the prototyping equations and solutions. Unit testing is to test the individual units such as functions, procedures, or object-oriented classes. System testing is to test the integrated system after the unit testing is done. The unit testing and system testing shall be performed by the software developer(s) (Cybernology). Acceptance testing will be performed by FCDMC for the final software acceptance. The documentations stage includes documenting findings in Phase 1, all testing reports, software user's manual, example-based tutorials, and source code listing. The deliverable stage is to prepare and deliver the software package (executable files, DLLs, etc.), source code, and documentations. In this phase, four brief progress reports and one final report shall be prepared and submitted to FCDMC.

1.3.1 Task 2.1 Preliminary Design

The preliminary design is to identify the major tasks and the resulting functions, procedures, or classes. The focus of the code development will be the efficiency (speed), accuracy, and convergence. The code shall be designed to achieve its robustness without any manipulation of parameters by the users. One method would be to design the code such that if the solution does not converge for certain time period, less complex partial differential equations shall be solved automatically. If the solution still does not converge, the "easiest" form of partial differential equations shall be solved automatically. In the preliminary design, functional or object-oriented design diagrams or traditional charts shall be prepared.

The final software shall be an executable file or set of executable files (with or without DLLs or components) which will be run on a specified schedule (like a batch file) by another different computer program for geographic information system (GIS) visualization. The GIS visualization program will be developed by the FCDMC staff.

The operating system for software development and deployment is Windows 2000. However, Linux shall be investigated regarding the computation performance improvement. Since parallel computation shall be investigated, Cybernology will make recommendations about the hardware (single processor or multi-processor) and operating system.

The real-time data input for the final software is real-time rainfall data (ALERT and National Weather Service radar data) for the entire County. The output for the software includes two parts. One part is the time series data (with a

specified time step) for flow depths and velocities for the entire County. Another part is contour-like data display for the maximum flow depth and velocity for the next forecasting time period. This part involves the development or direct use of standard contour-generation algorithms such as Marching Square algorithm. The formats for the inputs and outputs will be determined later. The ArcInfo grid ASCII file format may be used for the real-time spatial rainfall data. Simple ASCII format may be used to report the flow depth and velocity time series data. ArcView Shape file format may be used for reporting the maxim flow depth and velocity. The white paper for ArcView Shape file may be obtained from FCDMC, which documents the binary format of ArcView Shape file.

Necessary data shall be collected from FCDMC, which include sample rainfall data, topographic data (ground elevation), soil data with rainfall infiltration parameters, land use data, flow roughness coefficients, and so on for the entire County. The data format shall be in GIS format. The format details will be discussed between the consultant and FCDMC.

As a part of the algorithm and software development, a pre-processor shall be developed to determine which area in the County should be modeled based on real-time rainfall data, which will save computation time tremendously. In addition, the software shall be designed in a way such that it will also allow users to specify any locations where inflows will be given by the users to simulate a dam breach or dike breach. Hydraulics structures such as culverts, bridges and storm drains shall be included into the distributed modeling. The hydraulic structures can be simulated by using empirical equations and one-dimensional modeling. Since the software will be used for design storm modeling, it is required that the software can track the drainage area to each grid element. This will be used in Phase 3.

The consultant shall prepare a brief progress report and submit the report with the preliminary design to FCDMC for review and approval. The report shall be in both hard copy and digital format (MS Word or PDF).

1.3.2 Task 2.2 Detailed Design

The consultants shall elaborate the preliminary design to produce "code-to" specifications. The design documentation shall be developed with the programmer as the intended audience. The detailed design includes the following as appropriate for the specific task (1) functional or object-oriented design diagrams or traditional flowcharts; (2) descriptions of each unit (i.e,. function, sub-routine, and object); (3) descriptions of all users input, system output, and input/output files; (4) descriptions of all user interfaces (including the GUIs) if any; (5) descriptions of internal interfaces; (6) discretized PDEs and its solution scheme; (7) descriptions of all variables and methods used in the objects; and (9) code documentation (comment lines in the code).

The consultant shall prepare a brief progress report and submit the report with the detailed design to FCDMC for review and approval. The report shall be in both hard copy and digital format (MS Word or PDF).

1.3.3 Task 2.3 Testing Plan Development

The consultant shall prepare a testing plan that will specify all tests to be performed. Testing consists of three parts. Part One is unit testing where the individual units are to be tested separately. Part Two is system testing which is

to test the integrated system. A list, table or chart, and a report shall be prepared to document what and how the testing will take place. The testing shall be performed by two groups of people. Group One shall be the developers who actually will write the code based on the detailed design. Testing to be performed by Group One is part of the coding process. Group Two shall be the independent developers who are not involved in the development, coding or debugging. It should be noted that the term "independent developer" is defined as a programmer/developer who does not write the code. Code reading (line by line) is required for Group Two. The software testing shall also be based on hand-calculations. Basic calibration shall be performed in this phase to ensure the software will make reasonably accurate flood prediction.

The consultant shall prepare a brief progress report and submit it with the testing plan to FCDMC for review and approval. The report and testing plan shall be submitted to FCDMC in both hard copy and digital format (MS Word or PDF).

1.3.4 Task 2.4 Coding and Unit Testing

Coding shall be based on the detailed design. Coding includes prototyping and the full implementation of the algorithms by using C++ or FORTRAN. Prototyping is to solve the "easiest" PDEs which require the least computation time without losing much accuracy. The full implementation of the algorithms shall be based on the prototyping and expanded based on the algorithms developed in Task 1.3. Unit testing/debugging shall be performed by software Group One and Group Two developers to make sure the individual units will function correctly. The definitions for Group One and Group Two are found in Task 2.3. Detailed comments shall be added to the source code to explain the variables, methods, procedures, and algorithms. The comments added in the source code must be updated whenever changes are made to the source code.

1.3.5 Task 2.5 System Testing

After the unit testing is finished and errors uncovered in the unit testing are fixed, all units shall be integrated into one system. The integrated system shall be tested based on the testing plan by Group One and Group Two (see Task 2.3 for the definitions of Group One and Group Two). Any errors uncovered by system testing shall be corrected in this stage.

The consultant shall prepare a brief progress report on Task 2.4 and 2.5 and submit it to FCDMC for review and approval. The report shall be submitted to FCDMC in both hard copy and digital format (MS Word or PDF).

1.3.6 Task 2.6 Acceptance Testing

FCDMC will review the testing reports and will perform acceptance testing as end-users to make sure the requirements and specifications are to be met. The consultant shall submit all the digital files used for unit testing and system testing. The consultant may be required to perform more unit testing and system testing under FCDMC's direction. Any errors uncovered in this phase shall be corrected by the consultant.

If no errors are found in the acceptance testing, no additional system testing is necessary. If errors are found and corrected, more unit testing and system testing shall be performed by the consultant. This may involve a few iterations between FCDMC and the consultant.

1.3.7 Task 2.7 Documentations and Final Deliverables

The documentations include findings in Phase 1, testing-plans, all progress reports, software user's manual, example-based tutorials, and source code printout. A final report shall also be prepared. All reports must be in both hard copy format and digital format (MS Word or PDF). All documentations must be submitted to FCDMC for review and approval.

The consultant shall deliver FCDMC the final version of the software package (executable files, DLLs, etc.), source code, and all documentations.

1.4 Phase 3: Real-time PDE Parameter Calibration and Design Storm Post-Processing

Phase 3 consists of two parts. The first part is the algorithm development and software development for efficient real-time calibration of the partial differential equations for every short time period (say every 6-minute) based on the flow depths measured from the real-time ALERT stream gages throughout the County. In this phase, literature search/review shall first be conducted to collect and analyze the existing algorithms and software regarding the efficient real-time calibration. Methods that need to be investigated include, but not limited to, optimization techniques such as those used in solving ground water flow inverse problems, Kalman filter techniques, and so on. After the literature search is done, efficient algorithms shall be developed. Some simple algorithms may be developed in order to speed up the real-time calibration process. A report shall be prepared to document the literature search and the efficient algorithms for real-time calibration. The report must be submitted to FCDMC for review and approval.

After FCDMC's approval of the algorithms, the algorithms shall be implemented by following the general software guidelines as in Phase 2, which include preliminary design, detailed design, testing plan development, coding and unit testing, system testing, acceptance testing, documentations, and deliverables.

The second part of this phase is to develop the post-processing feature for the design storm modeling. The design storm is a 100-year storm derived by National Weather Service based on the statistical data. However, rainfall depth for the 100-year storm can not be directly used in the distributed modeling because the 100-year rainfall depth is the “point” rainfall depth and it is not the area-reduced rainfall depth. The area is defined as the drainage area. A series of area-reduced rainfall depth shall be computed and used as the input to the distributed model. The distributed model shall be run a few times, each of which corresponds to an area-reduced rainfall depth (index storm). Since the distributed model can track the drainage area to each grid, the flow depth, velocity, and flow rate for each grid can be computed by interpolation based on the results from the distributed model runs.

CYBERNOLOGY INC., 1024 N UTAH ST #722, ARLINGTON, VA 22201

Terms:	NET 30
Federal Tax ID Number:	14-1888463
Vendor Number:	141888463
Telephone Number:	303/941-9308
Fax Number:	703/248-0663
Contact Person:	Junping Wang
E-mail Address:	jwang@cybernology.net
Certificates of Insurance	Required
Performance Bond Required	$170,000.00
Contract Period:	To cover the period ending **October 31, 2004**.